PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ^{7} : E21B 33/16, 33/126	A1	(11) International Publication Number: **WO 00/66879** (43) International Publication Date: 9 November 2000 (09.11.00)

(21) International Application Number: PCT/US00/11525

(22) International Filing Date: 26 April 2000 (26.04.00)

(30) Priority Data:

60/132,044	30 April 1999 (30.04.99)	US
Not furnished	26 April 2000 (26.04.00)	US

(71) Applicant *(for all designated States except US)*: FRANK'S INTERNATIONAL, INC. [US/US]; Suite 300, 11700 Old Katy Road, Houston, TX 77079 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: HAWKINS, Samuel, P. [US/US]; 912 Hood Street, Mineral Wells, TX 76067 (US). LATIOLAIS, Burney, J., Jr. [US/US]; 203 Saddlewood Corner, Lafayette, LA 70508 (US). LUTGRING, Keith, T. [US/US]; 1024 Marilyn Drive, Lafayette, LA 70503 (US). BUTTERFIELD, Charles, A. [US/US]; 4810 Copperwood, Duncan, OK 73533 (US). BATES, Robert, A. [US/US]; 1016 Rebecca Lane, Houma, LA 70360 (US). LAUREL, David, F. [US/US]; 16331 Wytchwood Circle, Cypress, TX 77429-48509 (US).

(74) Agent: JOHNSON, William, E., Jr.; The Matthews Firm, Suite 1800, 1900 West Loop South, Houston, TX 77027-3214 (US).

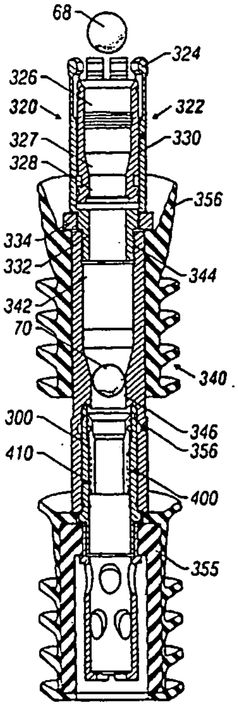
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND MULTI-PURPOSE APPARATUS FOR CONTROL OF FLUID IN WELLBORE CASING

(57) Abstract

A downhole apparatus is described as having an upper mandrel (320) shearably connected to a lower mandrel (360). A sleeve (300) is shearably connected within the lower mandrel (360). The operation of the apparatus involves dropping a first small diameter ball (70) from the earth's surface. The ball (70) travels through the upper mandrel (320) and settles into the sleeve (300). By increasing pump pressure at the earth's surface, the lower mandrel (360) is separated from the upper mandrel (320) by shearing. By further increasing the pump pressure, the lower mandrel (360) can be pumped down to the bottom of the tubular string against a float collar or other plug landing surface. When it is desired to separate the upper mandrel (320) from the tubular string, a second larger ball (68) is dropped from the earth's surface and is seated within the upper mandrel (320). By further increasing the pump pressure, the upper mandrel (320) is separated from the tubular string.



BEST AVAILABLE COPY

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

METHOD AND MULTI-PURPOSE APPARATUS FOR CONTROL OF FLUID IN WELLBORE CASING

FIELD OF INVENTION

This invention relates generally to equipment used in the drilling, completion and workover of subterranean wells and more specifically, to the control of drilling fluids, completion fluids, workover fluids, cement, and other fluids in a casing or other tubular string within a wellbore.

RELATED APPLICATION

This application claims priority from United States Provisional Patent Application, Serial No. 60/132,044, filed April 30, 1999.

BACKGROUND

The process of drilling subterranean wells to recover oil and gas from reservoirs consists of boring a hole in the earth down to the petroleum accumulation and installing pipe from the reservoir to the surface. Casing is a protective pipe liner within the wellbore that is cemented into place to ensure a pressure-tight connection of the casing to the earth formation containing the oil and gas reservoir. The casing is run a single joint at a time as it is lowered into the wellbore. On occasion, the casing becomes stuck and is unable to be lowered into the wellbore. When this occurs, load must be added to the casing string to force the casing into the wellbore, or drilling fluid must be circulated down the inside diameter of the casing and out of the casing into the annulus in order to free the casing from the wellbore. To accomplish this, it has traditionally been the case that special rigging be installed to add axial load to the casing string or to facilitate circulating the drilling fluid.

When running casing, drilling fluid is added to each joint as it is run into the well. This procedure is necessary to prevent the casing from collapsing due to high pressures within the annulus inside the wellbore exterior to the casing. The drilling fluid acts as a lubricant which facilitates lowing the casing within the wellbore. As each joint of casing is added to the string, drilling fluid is displaced from the wellbore. The prior art discloses hose assemblies, housings coupled to the uppermost portion of the casing, and tools suspended from the drill hook for filing the casing. These prior art devices and assemblies have been labor intensive to install, required multiple such devices for multiple casing string sizes, have not adequately minimized loss of drilling fluid, and have not been multi-purpose. Further, disengagement of the prior art devices from the inside of the casing has been problematic, resulting in damage to equipment, increased downtime, loss of drilling fluid, and injury to personnel.

Circulating of the drilling fluid is sometimes necessary if resistance is experienced as the casing is lowered into the wellbore. In order to circulate the drilling fluid, the top of the casing must be sealed so that the casing may be pressurized with drilling fluid. Since the casing is under pressure, the integrity of the seal is critical to safe operation and to minimize the loss of the expensive drilling fluid. Once the casing reaches the bottom, circulating of the drilling fluid is again necessary to test the surface piping system, to condition the drilling fluid in the hole and to flush out wall cake and cuttings from the hole. Circulating is continued until at least an amount of drilling fluid equal to the volume of the inside diameter of the casing has been displaced from the casing and the wellbore. After the drilling fluid has been adequately circulated, the casing may be cemented into place.

The purpose of cementing the casing is to seal the casing to the wellbore formation. In order to cement the casing within the wellbore, the assembly to fill and circulate drilling fluid is generally removed from the drilling rig and a cementing head apparatus installed. This process is time consuming, requires significant manpower, and subjects the rig crew to potential injury when handling and installing the additional equipment to flush the mud out with water or other chemical prior to the cementing step. A special cementing head or plug container is installed on the top portion of the casing being held in place by the elevator. The cementing head includes connections for the discharge line of the cement pumps, and typically includes a bottom and top wiper plug. Since the casing and wellbore are full of drilling fluid, it is first necessary to inject a spacer fluid to segregate the drilling fluid from the cement to follow. The cementing plugs are used to wipe the inside diameter of the casing and serve, in conjunction with the spacer fluid, to separate the drilling fluid from the cement as the cement is pumped down the casing string. Once the calculated volume of cement required to fill the annulus has been pumped, the top plug is released from the cementing head. Drilling fluid or some other suitable fluid is then pumped in behind the top plug, thus transporting both plugs and the cement contained between the plugs to an apparatus at the bottom of the casing known as a float collar. Once the bottom plug seals the bottom of the casing, the pump pressure increases, rupturing, for example, a diaphragm in the bottom of the plug and allowing the calculated amount of cement to flow from the inside diameter of the casing to a certain level within the annulus being cemented. The annulus is the space within the wellbore between the inside diameter ("ID") of the wellbore and the outside diameter ("OD) of the casing string. When the top plug comes in contact with the bottom plug, pump pressure increases, indicating that the cementing process has been completed. Once the pressure is lowered inside the casing, a special float collar check valve closes, keeping the cement from flowing from the OD of the casing back into the ID of the casing.

The prior art typically discloses separate devices and assemblies for (i) filling and circulating drilling fluid; and (ii) cementing operations. The prior art devices for filling and circulating drilling fluid disclose a packer tube, which requires a separate activation step once the tool is positioned within the casing. The packer tubes are known in the art to be subject to malfunction due to plugging, leaks, and the like, leading to downtime. Since each step in the well drilling process is potentially dangerous, time consuming, labor intensive and therefore expensive, there remains a need in the art to minimize any downtime. One advantage in this art is described in United States Patent No. 5,735,348, issued on April 7, 1998 to Samuel P. Hawkins for "Method and Multi-Purpose Apparatus for Dispensing and Circulating Fluid in Wellbore Casing," some of the components of which can be used, as but one example, in using the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1:	Illustrates sequentially the effects of dropping a pair of balls from the earth's surface into the downhole apparatus according to the present invention.
Figure 2:	Illustrates the sleeve which is moved down by dropping the first of two balls from the earth's surface and increasing the pump pressure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 1(a), there is illustrated an upper cylindrical mandrel 320, having an upper sub-mandrel 322, the upper end 324 of the sub-mandrel 322 comprising an externally flared, contractible collet. The invention contemplates the use of two balls, one being referred to as a small ball, and one as a larger ball. The upper sub-mandrel 322 has three progressively smaller axial bores, commencing at the collet end 324 with axial bore 326 followed by axial bores 327 and 328, axial bore 328 being sized to allow passage of a smaller ball, but not a larger ball. A first section 330 of the external side wall of the sub-mandrel 322 is threaded and of reduced diameter of the remainder of the sub-mandrel 322. A second section 332 of the external side wall is threaded and of an even smaller diameter than that of section 330. The section 330 has a male thread, around which a shoulder ring 334 is threadedly connected.

Referring further to Figure 1(a), a lower sub-mandrel 340, being part of the upper mandrel 320, has a first axial bore 342, the upper end of which has a female thread 344 to accept the male thread of section 332. The axial bore 342 tapers inwardly to a reduced diameter axial bore 346, through which a smaller ball can pass.

The external wall of the sub-mandrel 340 has a reduced diameter section 350 and a larger diameter section 352 on its end. The transition between the sections 350 and 352 forms a shoulder 351. A conventional elastomeric cement plug 356 is sized to fit over the section 350 and is locked into place between the shoulder 351 and the shoulder ring 334.

The section 352 has a larger diameter axial bore , approximately the same diameter as axial bore 327. The interior side wall of the axial bore 352 has a circular groove 354 for accepting a plurality of round balls, preferably of glass, ceramic or other drillable materials. In the preferred embodiment, four such balls (not illustrated) are used in the groove 354. One or more threaded holes 356 are in the side wall of section 352 and which feed into the groove 354. After the four balls are fed into the groove 354, a plug (not illustrated) is threadedly connected into each of the holes 356 to block them off and keep the balls captured in the groove 354.

Referring further to Figure 1(a), a lower mandrel 360 comprises a cylindrical lower-sub-mandrel 362 and a cylindrical upper sub-mandrel 364. The sub-mandrel 362 has a first axial bore 366 sized to accept the sleeve 300 of Figure 2, but a reduced diameter axial bore 368 which will initially block the flared, contractible collet end 306 of sleeve 300. The side wall 370 around the axial bore 366 has a plurality of holes 372 therethrough, preferably four holes in which the glass or plastic balls can reside while also in the groove 354. A plurality of shear pins, preferably four, are threaded through the sidewall 370 of the axial bore 368 to ride in the longitudinal slots in sleeve 300, illustrated in FIG. 2. A pair of grooves 380 and 382 are formed in the exterior side walls and around axial bores 366 and 368, respectively, and are used to house o-rings (not illustrated) for preventing fluid loss between the sub-mandrel 364 and the sub-mandrel 340.

The sub-mandrel 362 has a raised shoulder 392 and a threaded (female) portion to threadedly engage a threaded (male) lower end 394 of the upper sub-mandrel 364. The lower sub-mandrel 364 has a raised shoulder 396. A conventional, elastomeric cement plug 355 is sized to fit over the threaded connection between the shoulders 392 and 396 and is secured to the lower mandrel 360 by such shoulders.

The lower sub-mandrel 362 has a plurality of holes 500 through its sidewall below the shoulder 396, and also has an end cap 502 at its lowermost end with an opening through the cap 502 of a diameter less than the axial bore 504 to which the holes 500 are connected. The cap 502 has a slot in its lower side to assist in making up the various threaded connections. The bore 504 is sized to accept the sleeve 300 all the way down to the cap 502, against which the sleeve 300 comes to rest.

Referring now to Figure 2, there is illustrated a cylindrical sleeve 300 having a first axial bore 302 of a diameter sized to accept a first dropped ball, *i.e.*, 1-5/8," and a second axial bore 304 sized to stop the first dropped ball. The upper end 306 comprises an externally flared, contractible collet.

External grooves 308, 310 and 312, perpendicular to the longitudinal axis of the sleeve 300, with grooves 308 and 310 at collet end 306, and groove 312 at the opposite end of the sleeve 300, use o-rings (not illustrated) to provide a fluid seal in the operation of the sleeve 300, described hereinbelow.

Four equally spaced longitudinal slots, of which only slots 406 and 408 are illustrated, are spaced about the periphery of the sleeve 300, parallel to the longitudinal axis of the sleeve 300, within which a pair of shear pins 400 and a pair of shear pins 410, respectively, can ride and are protected until the sleeve has moved sufficiently to shear the shear pin pairs 400 and 410.

In making up the tools illustrated in Figures 1 and 2, the lower mandrel 360 can be rotated with respect to the upper mandrel 320 to align the holes 372 and 356 to feed the small "marble sized" balls into the groove 354. The holes 356 are then plugged up. The sleeve 300 keeps the small balls in place within the groove 354 and holes 372, thus locking the upper mandrel 320 to the lower mandrel 360, while allowing rotation between the two mandrels.

In the operation of the system described herein, with the equipment ready to be run into the interior of the casing string, whether to circulate fluid, fill-up the casing, to cement the casing to the earth formation walls, or otherwise control fluid according to the preferred embodiment of the invention, the system requires that a pair of balls be dropped, a first smaller ball, *i.e.*, having a 1-5/8" diameter, and then a larger ball, *i.e.*, having a 1-7/8" diameter. The balls should be a drillable material in the event of malfunction requiring the entire apparatus to be drilled out. The balls can be dropped manually, or can be dropped sequentially through the use of various ball-drop mechanisms known in the art.

As soon as the smaller ball enters the top end of the upper mandrel 320 of Figure 1(a), it passes all the way down to the sleeve 300 residing in the upper end of lower mandrel 360. By increasing pump pressure at the earth's surface and hence, by increasing differential fluid pressure across the first dropped ball 70, the sleeve 300 shears the first set of shear pins 400, at a predetermined pressure, *i.e.*, 1,000 psi. This causes the sleeve 300 to move down and uncover the small balls in the groove 354 and holes 356, allowing the small balls to drop out and the lower mandrel to separate from the upper mandrel, as illustrated in FIG. 1(b). As the now separated lower mandrel 360 is pumped down after being separated from the upper mandrel 320, it comes to rest against a float collar or other plug landing surface commonly used in this art at or near the bottom of the casing string. As a special feature of the present invention, means are provided for bending over and holding the ball 70 from falling out of its seating arrangement within the sleeve 300. By further increasing pump pressure at the earth's surface, the differential fluid pressure across the first dropped ball increases to a predetermined value, *i.e.*, to 1,250 psi, shearing a second set of shear pins 410, and forcing the collet end of the sleeve to be forced through the axial bore 368, resulting in the sleeve 300 coming to rest against the end cap 402. When the sleeve 300 bottoms out, this causes the plurality of holes 400 to be uncovered, allowing fluid to be pumped out of the holes 400, either to fill up the casing, to circulate fluid, to cause cement to exit out of the casing, or to otherwise control fluid in a casing string.

When the operator desires to separate the top mandrel, the second, largest ball is dropped. The second dropped ball reaches the narrowed-down opening 327 to axial bore 328, and seals off that opening. By increasing pump pressure to a predetermined amount, *i.e.*, 1,500 psi, the collet end 324 of the upper mandrel is pulled out of a fill-up and circulation tool or whatever other tool or apparatus is located immediately above the upper mandrel, shearing any shear pins as necessary and thus, the top cement plug can be pumped down the interior of the casing string. As a final step, the top mandrel is pumped down until it settles over the lower mandrel and the job is completed, usually by drilling out the lower and upper mandrels with their respective cement plugs.

In an alternative embodiment of using the apparatus according to the present invention, when it is desired to circulate fluids or fill up the casing with fluids, and it is not necessary, nor desired, to have the cement plugs be separated from the apparatus as contemplated by FIG. 1, the entire assembly comprised of the first and second cement plugs can be separated as a unit merely by dropping the second, large ball without having dropped the first, smaller ball, or upper mandrel 320 and the lower mandrel 360 can be bolted securely together, resulting in the ability to move the sleeve 300 down to uncover the holes 400 without separating the lower mandrel 360 from the upper mandrel 320.

CLAIMS

What is claimed is:

1. A method for allowing fluid to be pumped out of the lower end at a tubular string suspended in an earth borehole, comprising;

dropping a first ball of a given diameter into the upper end of said tubular string, and allowing said first ball to come to rest within the upper end of a sleeve positioned between the lower end of an upper mandrel and the upper end of a lower mandrel, said upper and lower mandrels being positioned within the interior of said tubular string, and said sleeve having an internal diameter less than said given diameter;

increasing at the earth's surface, to a first pressure level, the pump pressure of a fluid pumped into the said upper end of said tubular string and against said first ball to shear a first set of shear pins maintaining said sleeve within said upper mandrels, thereby causing said lower mandrel to separate from said upper mandrel, and for said lower mandrel to come to rest against a float collar or other plug landing surface positioned at the lower end of said tubular string;

increasing at the earth's surface, to a second pressure level higher than said first pressure level, the pump pressure of the fluid pumped into the said upper end of said tubular string and against said first ball to shear a second set of shear pins to move said sleeve downwardly within said lower mandrel, thereby allowing fluid to be pumped through said float collar or other plug landing surface and out of the tubular string into the earth borehole.

2. The mandrel according to Claim 1, wherein said lower mandrel comprises a support for an elastomeric cement plug.

3. A method for allowing fluid to be pumped out of the lower end at a tubular string suspended in an earth borehole, comprising;

dropping a first ball of a given diameter into the upper end of said tubular string, and allowing said first ball to come to rest within the upper end of a sleeve positioned between the lower end of an upper mandrel and the upper end of a lower mandrel, said upper and lower mandrels being positioned within the interior of said tubular string, and said sleeve having an internal diameter less than said given diameter;

increasing at the earth's surface, to a first pressure level, the pump pressure of a fluid pumped into the said upper end of said tubular string and against said first ball to shear a first set of shear pins maintaining said sleeve within said upper mandrel, thereby causing said lower mandrel to separate from said upper mandrel, and for said lower mandrel to come to rest against a float collar or other plug landing surface positioned at the lower end of said tubular string;

increasing at the earth's surface, to a second pressure level higher than said first pressure level, the pump pressure of the fluid pumped into the said upper end of said tubular string and against said first ball to shear a second set of shear pins to move said sleeve downwardly within said lower mandrel, thereby allowing fluid to be pumped through said float collar or other plug landing surface and out of the tubular string into the earth borehole;

dropping a second ball of a diameter greater than the given diameter of said first ball, into the upper end of said tubular string, and allowing said second ball to come to rest within an opening in said upper mandrel having an internal diameter less than the diameter of said second ball; and

applying at the earth's surface and against said second ball a pressure sufficient to cause said second upper mandrel to separate from said tubular string.

4. The method according to Claim 3, wherein said lower mandrel comprises a support for a first elastomeric cement plug, and said upper mandrel comprises a support for a second elastomeric cement plug.

5. The method according to Claim 4, including the additional step of pumping the upper mandrel down against the upper end of said lower mandrel.

6. A method for allowing fluid to be pumped out of the lower end at a tubular string suspended in an earth borehole, comprising;

dropping a first ball of a given diameter into the upper end of said tubular string, and allowing said first ball to come to rest within the upper end of a sleeve positioned between the lower end of an upper mandrel and the upper end of a lower mandrel, said upper and lower mandrels being positioned within the interior of said tubular string, and said sleeve having an internal diameter less than said given diameter;

increasing at the earth's surface, to a first pressure level, the pump pressure of a fluid pumped into the said upper end of said tubular string and against said first ball to shear a first shear pin maintaining said sleeve within said upper mandrels, thereby causing said lower mandrel to separate from said upper mandrel, and for said lower mandrel to come to rest against a float collar or other plug landing surface positioned at the lower end of said tubular string;

increasing at the earth's surface, to a second pressure level higher than said first pressure level, the pump pressure of the fluid pumped into the said upper end of said tubular string and against said first ball to shear a second shear pin to move said sleeve downwardly within said lower mandrel, thereby allowing fluid to be pumped through said float collar or other plug landing surface and out of the tubular string into the earth borehole.

7. The mandrel according to Claim 6, wherein said lower mandrel comprises a support for an elastomeric cement plug.

8. A method for allowing fluid to be pumped out of the lower end at a tubular string suspended in an earth borehole, comprising;

dropping a first ball of a given diameter into the upper end of said tubular string, and allowing said first ball to come to rest within the upper end of a sleeve positioned between the lower end of an upper mandrel and the upper end of a lower mandrel, said upper and lower mandrels being positioned within the interior of said tubular string, and said sleeve having an internal diameter less than said given diameter;

increasing at the earth's surface, to a first pressure level, the pump pressure of a fluid pumped into the said upper end of said tubular string and against said first ball to shear a first shear pin maintaining said sleeve within said upper mandrel, thereby causing said lower mandrel to separate from said upper mandrel, and for said lower mandrel to come to rest against a float collar or other plug landing surface positioned at the lower end of said tubular string;

increasing at the earth's surface, to a second pressure level higher than said first pressure level, the pump pressure of the fluid pumped into the said upper end of said tubular string and against said first ball to shear a second shear pin to move said sleeve downwardly within said lower mandrel, thereby allowing fluid to be pumped through said float collar or other plug landing surface and out of the tubular string into the earth borehole;

dropping a second ball of a diameter greater than the given diameter of said first ball, into the upper end of said tubular string, and allowing said second ball to come to rest within an opening in said upper mandrel having an internal diameter less than the diameter of said second ball; and

applying at the earth's surface and against said second ball a pressure sufficient to cause said second upper mandrel to separate from said tubular string.

9. The method according to Claim 8, wherein said lower mandrel comprises a support for a first elastomeric cement plug, and said upper mandrel comprises a support for a second elastomeric cement plug.

10. The method according to Claim 9, including the additional step of pumping the upper mandrel down against the upper end of said lower mandrel.

11. An apparatus for controlling the flow of fluid out of the lower end of a tubular string suspended in an earth borehole, comprising;

a first, lower mandrel positionable within the interior of the tubular string and having a first internal fluid passageway along its length;

a second, upper mandrel, positionable within the interior of the tubular string and having a second internal fluid passageway along its length, and having a given internal diameter, said first and second fluid passageways being in fluid communication with each other; and

a sleeve locking said lower mandrel to said upper mandrel through the use of a first set of shear pins and wherein said sleeve is also locked to said lower mandrel through the use of a second set of shear pins, said sleeve having an internal diameter less than said given diameter, said first set of shear pins being shearable by a given force, and said second set of shear pins being shearable by a force greater than said given force, wherein dropping a first ball having a diameter less than the given internal diameter of the upper mandrel and thereafter increasing the pump pressure of the fluid at the earth's surface, and thereby supplying such pressurized fluid through the tubular string to said upper and lower mandrels, shears said first set of shear pins and causes the lower mandrel to separate from the upper mandrel.

12. The apparatus according to Claim 11, being further characterized by a collect connection located at the top end of said upper mandrel for forming a connection between said tubular string and said upper mandrel.

13. The apparatus according to Claim 11, being further characterized by a float collar or plug landing surface located at the lower end of said lower mandrel.

14. An apparatus for controlling, through the use of two dropped balls and an increase of the pump pressure at the earth's surface, the flow of fluid out of the lower end of a tubular string suspended in an earth borehole, comprising;

a first, lower mandrel;

a sleeve shearably connected within the interior of said lower mandrel by a first set of shear pins and having a first receptacle with a first given diameter for receiving and holding a first dropped ball having a diameter greater than said first given diameter;

a second-upper mandrel shearably connected to said lower mandrel by a second set of shear pins, said upper mandrel having a second receptacle with a second given diameter for receiving and holding a second dropped ball having a diameter greater than the diameter of said second given diameter, the diameter of said first dropped ball being smaller than the diameter of said second dropped ball.

15. An apparatus for controlling, through the use of two dropped balls and the increase of the pump pressure at the earth's surface, the flow of fluid out of the lower end of a tubular string suspended in an earth borehole, comprising;

a first, lower mandrel;

a sleeve shearably connected within the interior of said lower mandrel by a first shear pin and having a first receptacle with a first given diameter for receiving and holding a first dropped ball having a diameter greater than said first given diameter;

a second upper mandrel shearably connected to said lower mandrel by a second shear pin, said upper mandrel having a second receptacle with a second given diameter for receiving and holding a second dropped ball having a diameter greater than the diameter of said second given diameter, the diameter of said first dropped ball being smaller than the diameter of said second dropped ball.

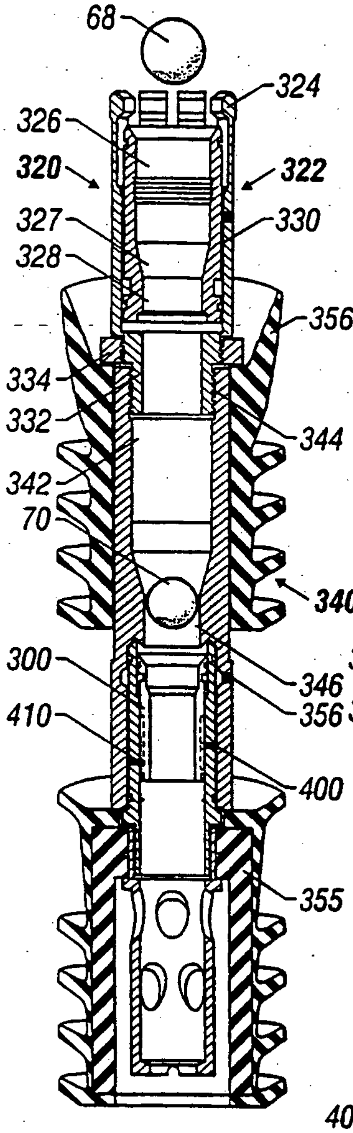


Fig 1A

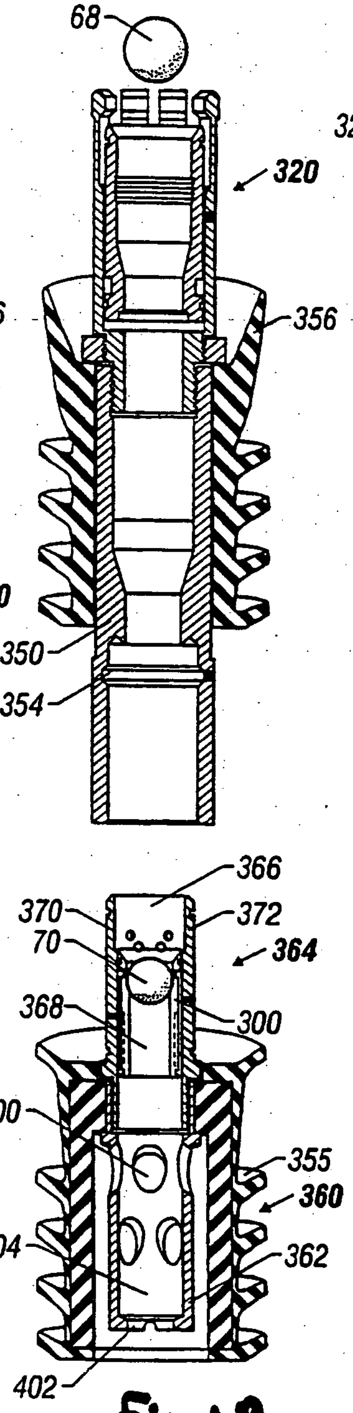


Fig. 1B

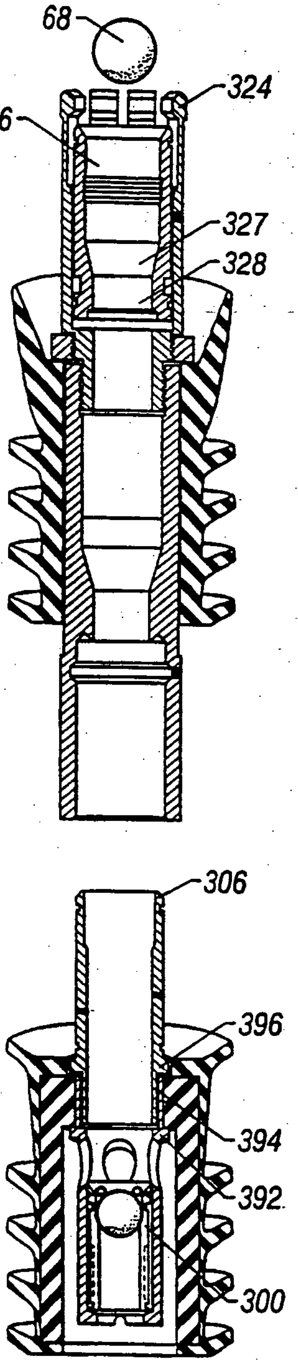


Fig 1C

FIG. 9

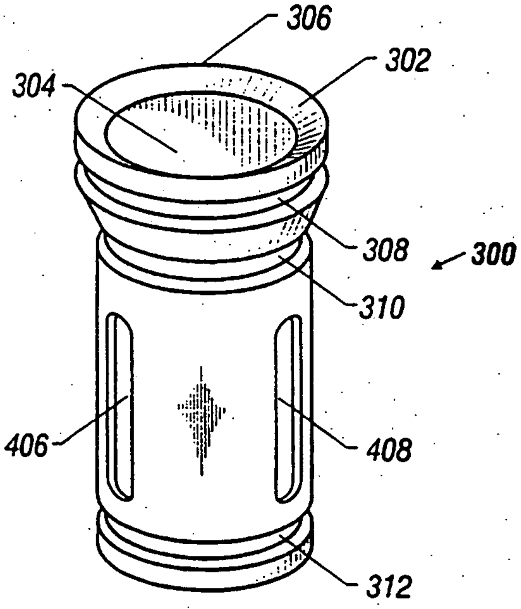


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/11525

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :E21B 33/16, 33/126
US CL : 166/153, 177.4, 193, 194, 317, 318, 376, 377, 386
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 166/153, 156, 177.4, 193, 194, 291, 317, 318, 374, 376, 377, 383 386

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,722,491 A (SULLAWAY ET AL) 03 March 1998 (03.03.98), see entire document.	1-15
A	US, 5,413,172 A (LAUREL) 09 May 1995 (09.05.95), see Figures 2C and 4-6.	1-15
A	US 3,730,267 A (SCOTT) 01 May 1973 (01.05.73), see entire document.	1-15
A	US 2,998,075 A (CLARK, JR.) 29 August 1961 (29.08.61), see entire document.	1-15
A	US 2,659,438 A (SCHNITTER) 17 November 1953 (17.11.53), see entire document.	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search 08 JUNE 2000	Date of mailing of the international search report 19 JUL 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer GEORGE SUCHFIELD Diane Smith for Telephone No. (703) 308-2168

Form PCT/ISA/210 (second sheet) (July 1998)★

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

☐ BLACK BORDERS

☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES

☐ FADED TEXT OR DRAWING

☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING

☐ SKEWED/SLANTED IMAGES

☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS

☐ GRAY SCALE DOCUMENTS

☐ LINES OR MARKS ON ORIGINAL DOCUMENT

☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY

☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)